Energy Efficient and Resource Friendly Trawl Systems

M.P. Remesan
Fishing Technology, Division, ICAR-Central Institute of Fisheries Technology, Kochi
E-mail: mpremesan@gmail.com

Increasing fuel consumption, fuel costs, greenhouse gas emission and related environmental and health impacts compel fisheries scientists to develop fuel efficient harvesting technologiesglobally. Tyedmers et al. (2005) reported that 50 billion litres of diesel is burnt by the global fishing fleet every year. Annual fuel consumption of the mechanised and motorised fishing fleet of India in 2010 was estimated as 1378.8 million litres releasing about 3.13 million tonnes of CO_2 at an average rate of 1.02 tonnes per live weight of marine fish landed (Vivekanandan, et al., 2013).

Trawling is the most energy intensive fishing methods in the world. It consumes 5 times the fuel compared to gillnetting and long lining and 11 times than purse seining operations. To catch 1kg of fish, trawling requires 0.8kg fuel, gillnetting 0.15, long lining 0.25 and purse seining 0.07kg (Gulbradson, 1986). Fuel consumption of trawlers which depends on installed engine horse power and duration of voyage constitute 45 to 75% of operational expenditure. Ravi, et al (2015) estimated total fuel consumption of mechanised trawl sector in Kerala as 106.3 million litres @ 0.41kg/kg of fish landed.

In addition to the type of fishing method employed, amount of fuel consumption vary depending on the size and design of the vessel, engine power, speed of propulsion, type and size of fishing gear and accessories, location of the ground, skill and knowledge of the crew, atmospheric and sea conditions.Similarly fishing gear design has a major role in determining the energy efficiency of a particular fishing systems.

As per CMFRI (2012) there are 35,228 trawlers in the country of size ranging from 9m-30 m and engine power 45 to 495 hp. Trawl size ranges from 25-106m with 12-14 mm ϕ PP rope used as head and foot ropes weight of the otter board ranging from 60-110kg Along with the introduction of larger vessels with high power engine large mesh trawls were also introduced for speed trawling and the mesh size in the wing went up to 10m. Along with increase in vessel size and engine power, the size of the trawls also increased proportionately and many of these trawlers practise multiday operations.

When the vessel size and engine power increased to equip them for multiday voyages the size of trawl net also increased which led to the increase in fuel consumption and operation expenditure of trawling.

Table 1. Profile of fuel consumption of mechanized trawlers in Kerala (Sayana, 2018)

Fuel use	Small trawlers (single day)	Small trawlers (multiday)	Medium trawlers	Large trawlers	Very large trawlers
Consumption per hour	6.12-8.75 (7.5)	15.3-18.9 (17.3)	17-23 (20.45)	26.7-32.3 (30.1)	43.86-52.8 (48.5)
Consumption per day	46-70 (60)	138-170 (155.71)	190-244 (225.0)	320.66-387.73 (361.07)	526.37-633.62 (582.27)
Consumption per trip	-	414-510 (467)	948.5-1219.5 (1125)	3207-3877 (3610)	6735-7345 (6987)
Consumption per year	11760-12312 (12036)	34095-36085 (35090.3)	46287-60243 (54722.0)	86438-97675 (90285)	140589-153246 (146732.5)

Trawl Drag

In trawling system vessel drag is the primary factor determining the fuel efficiency. In bottom trawling reduction of drag of the trawl net is identified as one of the most important factor for achieving fuel efficiency. Drag is the power required to overcome thehydrodynamic resistance of the towed gear at a particular speed. Estimation of drag can be done through model studies or using actual gear orcan be estimated theoretically (Hameed & Boopendranath, 2000).Estimation of drag of commercial trawls in Kerala reveals that it ranges from 1.37 to 48.94 kN (Sayana, 2018).

Factor determining drag of trawl system

Drag of a trawl system depends the quantity of webbing, otterboards, ground gear (bobbins and foot rope), number floats, sinkers, length of warp, bridles and other operational parameters. Accordingly warp contribute 5%, sweeps 4%, otterboards 20%, floats 3%, foot rope 10% and netting 58% to the total drag of a trawl (Wileman (1984).Tauti (1934) assumed that drag force is proportional to the square of the water velocity.

Drag depends on many factors such as design of trawl net, rigging, operating conditions such as nature of water currents (against or along current direction), depth of operation, type and length of warp, etc. Apart from the design netting material used,netting construction properties (braided or twisted),the knot factor (knotted and knotless netting); net design (sequence of tapers) andtrawl spread ratio.

Trawl drag can be reduced by reducing the size of trawl, making less opening in wing end spread and head line height, reducing twine surface area, reducing ground contact friction or using more efficient otterboards. Material of fabrication of webbing has significant effect on resistance, efficiency and selectivity of gears. Ward et al. (2005) suggested material and twine diameter as the measures need to be reduced to improve energy efficiency and the use of knotless netting

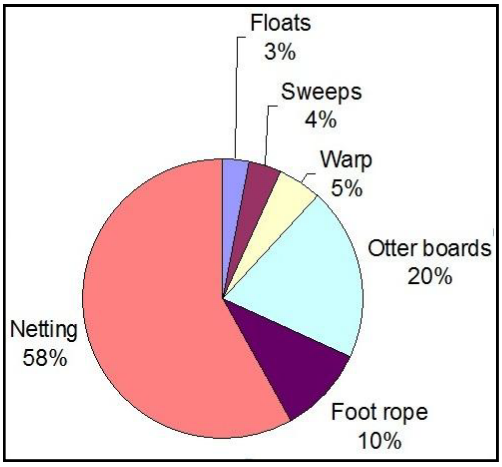

Fig.1. Drag of components of a trawl gear

Steps to reduce drag of trawl nets

No	Factors	Reduction in drag (%)
1	Operate multi-rig trawls	25-30
2	Use thinner twine	7
3	Use large meshes	7
4	Use knotless netting	7
5	Use curved otter boards (OBs)	4
6	Use optimal angle of attack for OBs	4
7	Use slotted OBs	2

(Wilman, 1984, and others)

Increasing the mesh size,reducing the twine thickness and twine surface area are supposed to reduce the drag offered by gear underwater. UHMWPE is a netting material which isstronger and thinner and with very low elasticity (Hansen &TØrring, 2012).

Similarly mesh orientation and mesh shape can also play an important role in reducingtrawl drag.Mesh orientation also helps to reduce the drag. Square mesh, T40 and T90 mesh will facilitate better mesh opening and water filtration and eliminate juveniles from the trawl apart from reduction in drag.Reduction in size of net, wing end spread, headline height are

other steps suggested for drag reduction in trawls.

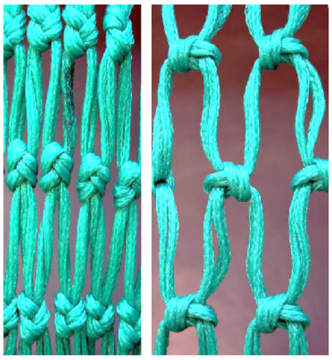

Fig. 2. Diamond mesh and T90 mesh

During calm weather conditions, major share of fuel is used to overcome the trawl drag compared to vessel propulsion intrawlers. In trawling operation, a sizeable time is spent for towing the gear and10-20% fuel consumed is spent to overcome the resistance (drag) during towing time. Hence it is understood that gear has a large effect on fuelconsumption during towing because drag due to vessel is insignificant at thetime of towing when compared to drag due to gear (Boopendranath, 2002).

Drag experienced in otterboards can be reduced by lifting them away from the bottom. CIFT- off bottom trawls use high aspect ratio otter boards and operate 0.5 -1.5m above sea bottom to reduce bottom impact and drag. Slotted otterboards also reduced drag as it allow the water to pass through the slots. Experiment with CIFT-double slotted boards showed better performance of the gear with less engine RPM as a result of drag reduction.

Fig. 3. Double slotted otter board

Low Drag Trawls developed at ICAR-CIFT

UHMWPE trawls

ICAR-Central Institute of Fisheries Technology (ICAR-CIFT) designed and fabricated low drag trawls for fish shrimp of head rope length 24.47 m 30.0 m respectively (Remesan, et al.2019).The drag reduction measures included in the design are increased mesh size and new material. The material used is ultra high molecular weight polyethylene (UHMWPE). As UHMWPE provides same strength with thinner twines, it would result in reduced twine area. For evaluation of new designs, trawl nets using conventional material, high density polyethylene (HDPE) is also fabricated and used as control. The experiments for evaluating the new design were conducted onboard M. V. Matsyakumari II. Data regarding dragand fuel consumption experienced for each operation were recorded using Warp Tension meter and Fuel flow meter fitted to the fuel line of the vessel. The depth of operation ranged from 10 to 20 m, the fishing speed was 3 to 4 kn and the warp length varied from 40 to 100 m

GigasenseTMWarp Tension Meter of 20 ton capacity was used to measure the drag acting on the towing warp. From the trials conducted, the average reduction in drag of new design is estimated to be 17%.

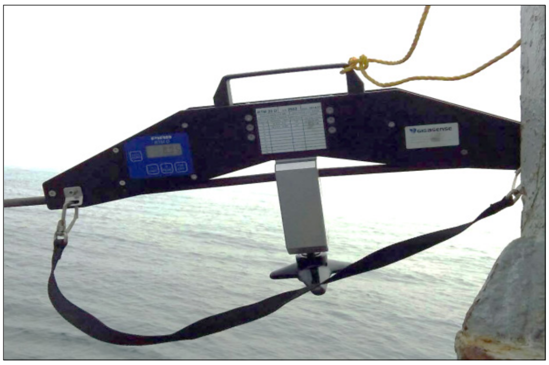

Fig. 4. Warp Tension Meteronboard MK-II

The average fuel consumption per one hour of trawling for HDPE trawls is estimated to be 30 litres and for UHMWPE trawls 26 litres. The average reduction in fuel consumption found to be 10%. The fuel consumption per kilogram of fish captured was also estimated and it is 2.9 litres for HDPE trawls and 1.9 litres for UHMWPE trawls and the average reduction is estimated to be 35%.

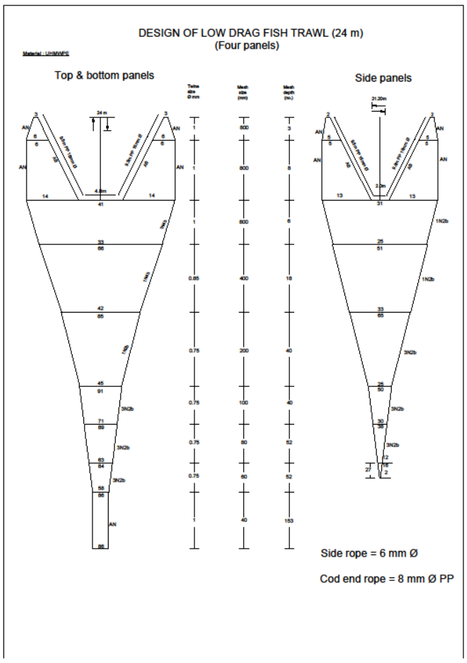

Fig. 5. Design of low drag shrimp trawl

Fig. 6. Low drag shrimp trawl trialsonboard MK-II

Fig. 7. Dr.Trilochan Mohapatra, Secretary DARE and DG, ICAR, releasing the LDT system technology onboard CIFT RV. SagarHarita

Cutaway top belly shrimp trawl

Modifying designs of trawl will help reduce drag as well as bycatch and discards. The cutaway shrimp trawlis a good example for that, which was designed based on the behavioural difference between fish and shrimp when encounter with the trawl. Shrimps roll along the bottom panel of the trawl when moving to the codend, whereas fishes actively swim up in the funnel and try to escape from the trawl. To reduce the drag the square and front portion of belly is removed and the net has long wings. The fishes can escape from the trawl mouth unhurt by clearing the head line.

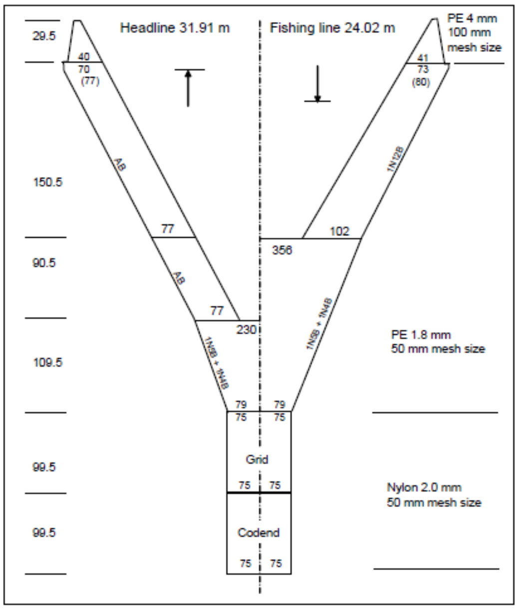

Fig. 8. Cutaway trawl used in Gulf of Maine pink shrimp fishery (source: He et al., 2007)

Short body shrimp trawl to reduce drag

CIFT has developed and successfully field tested a 27 m shrimp trawl with relatively short body and large horizontal spread suitable for selective retention of shrimp. The width and length of the trawl funnel has been reduced by increasing the tapering ratio and the vertical opening of the mouth has been reduced to eliminate bycatch. Because of the larger horizontal spread of the mouth the effective sweep area is more, which is the most vital requirement for a shrimp trawl.

Trials carried out along the coastal waters off Cochin with a prototype of short body shrimp trawl reveals considerable reduction in the catch fish due to the behavioral difference of the targeted species.

The results indicates that there was a significant reduction in the drag. Mmean catch per unit effort (CPUE kg.h-1) of non-targeted fin fishes (from 9.75 kg.h-1 to 2.75 kg.h-1) and bycatch generated for capturing per unit weight of shrimp (3.5 and 1.69 respectively for the commercial and short body trawl). The Ecological Use Efficiency (EUE) by Alverson and Hughes (1996) was used to see the ecological impact of bottom trawling and it was noticed that the EUE was 0.22 and 0.37 respectively for catches in the commercial and short body trawls indicating a better efficiency for the short body trawls.

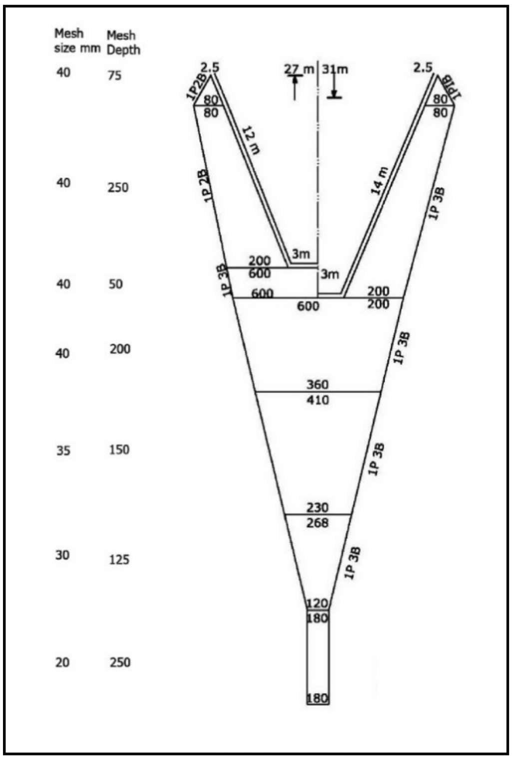

Fig. 9. Short body shrimp trawl

CIFT-Off Bottom Trawl

The system consists of a four panel trawl with double bridles, front weights and vertically cambered high aspect ratio otter boards of 85 kg each (Fig. 1).It is capable of attaining catch rates beyond 200 kg.h^{-1} in moderately productive grounds and selectively harvest fast swimming demersal and semi-pelagic finfishes and cephalopods, which are generally beyond the reach of conventional bottom trawls.

Fig. 10. High aspect ratio otter boards

Advantages

- Significantly high sheer-drag ratio of vertically cambered high aspect ratio otter boards, makes the system energy-efficient, compared to conventional flat rectangular and V-form otter boards. The vertically cambered high aspect ratio otter boards have dual-purpose capabilities and can also be deployed for conventional bottom trawling.
- Bottom impact of semi-pelagic trawl system is significantly lower, making it an ecologically friendly gear, compared to bottom trawls.
- CIFT OBTS has shown significant resource specificity for off-bottom (semi-pelagic) finfishes, which are generally large in size, fast swimming and exhibit shoaling characteristics
- Conventional bottom shrimp and fish trawls have low vertical opening, mostly limited to 1-1.5 m and hence their catches are limited to species living close to the bottom. Due to higher vertical opening up to 4.0 m realized in CIFT OBTS, resources that are beyond reach of conventional bottom trawls, could be efficiently harvested.

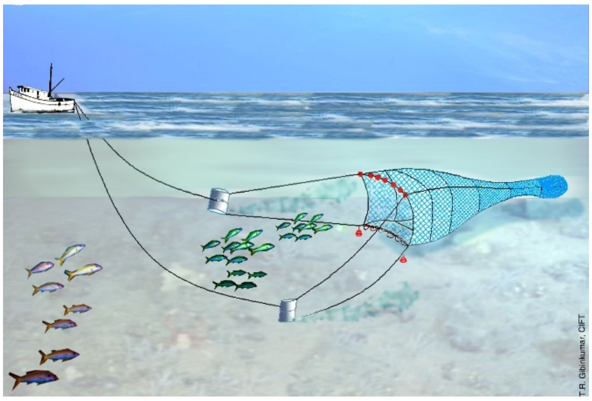

Fig. 11. CIFT-Off bottom trawl system

CIFT OBTS is indigenously developed and is best suited to Indian fishing conditions and fishery resources. The gear system has been developed and optimized taking into consideration ofbiological, behavioural and distribution characteristics of tropical demersal and semi-pelagic finfish and cephalopod resources and technical capabilities of the small-scale mechanized trawler fleet, operating in Indian waters.

Fig.12. Off-bottom trawls trials onboard MK-II

References/suggested reading

CIFT (2011) CIFT SPTS: Eco-friendly Semi-pelagic Trawl System for Small-scale Mechanized Sector, Central Institute of Fisheries Technology, Cochin

He, P., Doethel, D and Smith, T (2007) Design and test of a topless shrimp trawl to reduce pelagic fish bycatch in the Gulf of marine pink shrimp fishery. Journal of Northwest Atlantic Fishery Science 38:13-21DOI: 10.2960/J.v38.m591

Madhu, V.R, Remesan, M.P, Pravin, P and Boopendranath, M.R (2015). Cutaway top belly trawl-A new eco-friendly shrimp trawl design. In Book of Abstracts.p39. World Ocean Science Congress

Remesan, M.P., Madhu, V.R., Sayana, K.A., PrabeeshKumar, M.V.,Harikrishnan, K.R. and Edwin, L. (2017). Fuel saving throughmaterial substitution in trawls. Fish Tech Reporter 3(1):3-5

Remesan, M.P., Madhu, V.R., Sayana, K.A and Leela Edwin (2019) Low drag trawl for energy efficient fishing. Fishery Technology

Sayana, K.A., Ramesan, M.P., Madhu,V.R., Pravin, P. and Edwin, L. (2016) Appraisal of trawl design operated along Kerala coast. Fish. Technol. 53: 30-36

Sayana, K. A. Remesan, M. P Leela Edwin. (2018) Impact of operational parameters on drag of trawl nets. Fish. Technol. 55(4): 295 – 297

Sayana, K.A. Proliferating growth and fuel consumption of mechanised trawlers of Keralaand investigations on efficiency of low drag trawl. PhD Thesis. CUSAT 273p